Optomechanical Dirac Physics

M. Schmidt, V. Peano, F. Marquardt, arXiv:1410.8483 [cond-mat.mes-hall]

Recent progress in optomechanical systems may soon allow the realization of optomechanical arrays, i.e. periodic arrangements of interacting optical and vibrational modes. We show that photons and phonons on a honeycomb lattice will produce an optically tunable Dirac-type band structure. Transport in such a system can exhibit transmission through an optically created barrier, similar to Klein tunneling, but with interconversion between light and sound. In addition, edge states at the sample boundaries are dispersive and enable controlled propagation of photon-phonon polaritons.

Dynamics of optically injected currents in carbon nanotubes

L. L. Bonilla, M. Alvaro, M. Carretero, and E. Ya. Sherman, Phys. Rev. B 90, 165441

We consider theoretically the dynamics of electric currents optically injected in carbon nanotubes. Although the plasma oscillations are not seen in these systems, the main effect on the carrier's motion is due to strongly nonuniform space-charge Coulomb forces produced by time-dependent separation of injected electron and hole densities. We calculate the evolution of the dipole moment characterizing the time- and coordinate-dependent charge-density distributions and analyze different regimes of the dynamics. The developed time-dependent dipole moment leads to a dipole radiation in the THz frequency range for typical parameters of injected currents.

Room Temperature Electrical Detection of Spin Polarized Currents in Topological Insulators

André Dankert, Johannes Geurs, M. Venkata Kamalakar, and Saroj P. Dash, arXiv:1410.8038 [cond-mat.mes-hall]

Topological insulators (TIs) are a new class of quantum materials that exhibit spin momentum locking (SML) of massless Dirac fermions in the surface states. Usually optical methods, such as angle and spin-resolved photoemission spectroscopy, have been employed to observe the helical spin polarization in the surface states of three-dimensional (3D) TIs up to room temperatures. Recently, spin polarized surface currents in 3D TIs were detected by electrical methods using ferromagnetic (FM) contacts in a lateral spin-valve measurement geometry. However, probing the spin texture with such electrical approaches is so far limited to temperatures below 125K, which restricts its application potential. Here we demonstrate the room temperature electrical detection of the spin polarization on the surface of Bi_2Se_3 due to SML by employing spin sensitive FM tunnel contacts. The current-induced spin polarization on the Bi_2Se_3 surface is probed at room temperature by measuring a spin-valve signal while switching the magnetization direction of the FM detector. The spin signal increases linearly with current bias, reverses sign with current direction, exhibits a weak temperature dependence and decreases with higher TI thickness, as predicted theoretically. Our results demonstrate the electrical detection of the spin polarization on the surface of 3D TIs, which could lead to innovative spin-based quantum information technology at ambient temperatures.

Study of stability of topological crystalline insulators against disorder

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Noninteracting insulating electronic states of matter can be classified according to their symmetries in terms of topological invariants which can be related to effective surface theories. These effective surface theories are in turn topologically protected against the effects of disorder. Topological crystalline insulators are, on the other hand, trivial in the sense of the above classification but still possess surface modes. In this work we consider an extension of the Bernevig-Hughes-Zhang model that describes a topological crystalline insulator. We explicitly show that the surface properties of this state can be as robust as in topologically nontrivial insulators, but only if the S_z-component of the spin is conserved. However, in the presence of Rashba spin-orbit coupling this protection vanishes and the surface states localize, even if the crystalline symmetries are intact on average.

Fano-Josephson effect of Majorana bound states

Gao Zhen, Shu-Feng Zhang, Ying Zhao, Guangyu Yi, Wei-Jiang Gong, arXiv:1411.0468 [cond-mat.mes-hall]

We investigate the Josephson current in a Fano-Josephson junction formed by the direct coupling between two topological superconducting wires and their indirect coupling via a quantum dot. It is found that when two Majorana zero modes respectively appear in the wires, the Fano interference causes abundant Josephson phase transition processes. What is notable is that in the presence of appropriate direct and indirect inter-wire couplings, the fractional Josephson effect disappears and then such a structure transforms into a $\bar{0}$-phase normal Josephson junction. On the other hand, if finite coupling occurs between the Majorana bound states at the ends of each wire, the normal Josepshon current is robustly in the $\bar{0}$ phase, weakly dependent on the Fano effect. We believe that the results in this work are helpful for describing the Fano-modified Josephson effect.

Balanced homodyne detection with on-off detector systems: observable nonclassicality criteria

J. Sperling, W. Vogel, and G. S. Agarwal, arXiv:1410.8012 [quant-ph]
Driven by single photon detection requirements especially for quantum information sciences, the theory of arrays of off-on detectors has been well developed and applied. However for a comprehensive characterization of nonclassicality one also needs phase sensitive properties. This missing link is fulfilled by the theory of phase sensitive click counting measurements. This theory is presented. It unifies the balanced homodyne detection for high intensities with the click detection in the few photon regime. We formulate and apply a hierarchy of nonlinear squeezing conditions to probe quantum effects beyond standard squeezing. Imperfections stemming from fluctuations of the local oscillator, detector efficiency, and dark count rates are considered. Experimentally accessible sampling formulas are given which can be applied without time consuming data processing. Our phase-sensitive click detection theory paves the way towards novel applications of nonclassical light in quantum metrology.

Light-matter decoupling and A^2 term detection in superconducting circuits
Juan José García-Ripoll, Borja Peropadre, Simone De Liberato, arXiv:1410.7785 [quant-ph]
We study the spontaneous emission of a qubit interacting with a one-dimensional waveguide through a realistic minimal-coupling interaction. We show that the diamagnetic term A^2 leads to an effective decoupling of a single qubit from the electromagnetic field. This effects is observable at any range of qubit-photon couplings. For this we study a setup consisting of a transmon that is suspended over a transmission line. We prove that the relative strength of the A^2 term is controlled with the qubit-line separation and show that, as a consequence, the spontaneous emission rate of the suspended transmon onto the line can increase with such separation, instead of decreasing.

Quantized recurrence time in iterated open quantum dynamics
P. Sinkovicz, Z. Kurucz, T. Kiss, J. K. Asbóth, arXiv:1411.0568 [quant-ph]
The expected return time to the original state is a key concept characterizing systems obeying both classical or quantum dynamics. We consider iterated open quantum dynamical systems in finite dimensional Hilbert spaces, a broad class of systems that includes classical Markov chains and unitary discrete time quantum walks on networks. Starting from a pure state, the time evolution is induced by repeated applications of a general quantum channel, in each timestep followed by a measurement to detect whether the system has returned to the original state. We prove that if the superoperator is unital in the relevant Hilbert space (the part of the Hilbert space explored by the system), then the expectation value of the return time is an integer, equal to the dimension of this relevant Hilbert space. We illustrate our results on partially coherent quantum walks on finite graphs. Our work connects the previously known quantization of the expected return time for bistochastic Markov chains and for unitary quantum walks, and shows that these are special cases of a more general statement. The expected return time is thus a quantitative measure of the size of the part of the Hilbert space available to the system when the dynamics is started from a certain state.

Antibunching and unconventional photon blockade with Gaussian squeezed states
Marc-Antoine Lemonde, Nicolas Didier, Aashish A. Clerk, arXiv:1410.6510 [quant-ph]
Photon antibunching is a quantum phenomenon typically observed in strongly nonlinear systems where photon blockade suppresses the probability for detecting two photons at the same time. Antibunching has also been reported with Gaussian states, where optimized amplitude squeezing yields classically forbidden values of the intensity correlation, $g^{(2)}(0) < 1$. As a consequence, observing antibunching is not necessarily a signature of photon-photon interactions. To clarify the significance of the intensity correlations, we derive a sufficient condition for deducing if a field is non-Gaussian based on a $g^{(2)}(0)$ measurement. We then show that the Gaussian antibunching obtained with a degenerate parametric amplifier is close to the ideal case reached using dissipative squeezing protocols. We finally shed light on the so-called unconventional photon blockade effect predicted in a driven two-cavity setup with surprisingly weak Kerr nonlinearities, stressing that it is a particular realization of optimized Gaussian amplitude squeezing.

A magic state's fidelity can be superior to the operations that created it
Ying Li, arXiv:1410.7808 [quant-ph]
The leading approach to fault tolerant quantum computing requires a continual supply of magic states. When a new magic state is first encoded, its initial fidelity will be too poor for use in the computation. This necessitates a resource-intensive distillation process that occupies the majority of the computer's hardware; creating magic states with a high initial fidelity minimises this cost and is therefore crucial for practical quantum computing. Here we present the surprising and encouraging result that raw magic states can have a fidelity significantly better than that of the two-qubit gate operations used to construct them. Our protocol exploits post-selection without significantly slowing the rate of generation and tolerates finite error rates in initialisations, measurements and single-qubit gates. This approach may dramatically reduce the size of the hardware needed for a given quantum computing task.